Microbial Control of Arthropods

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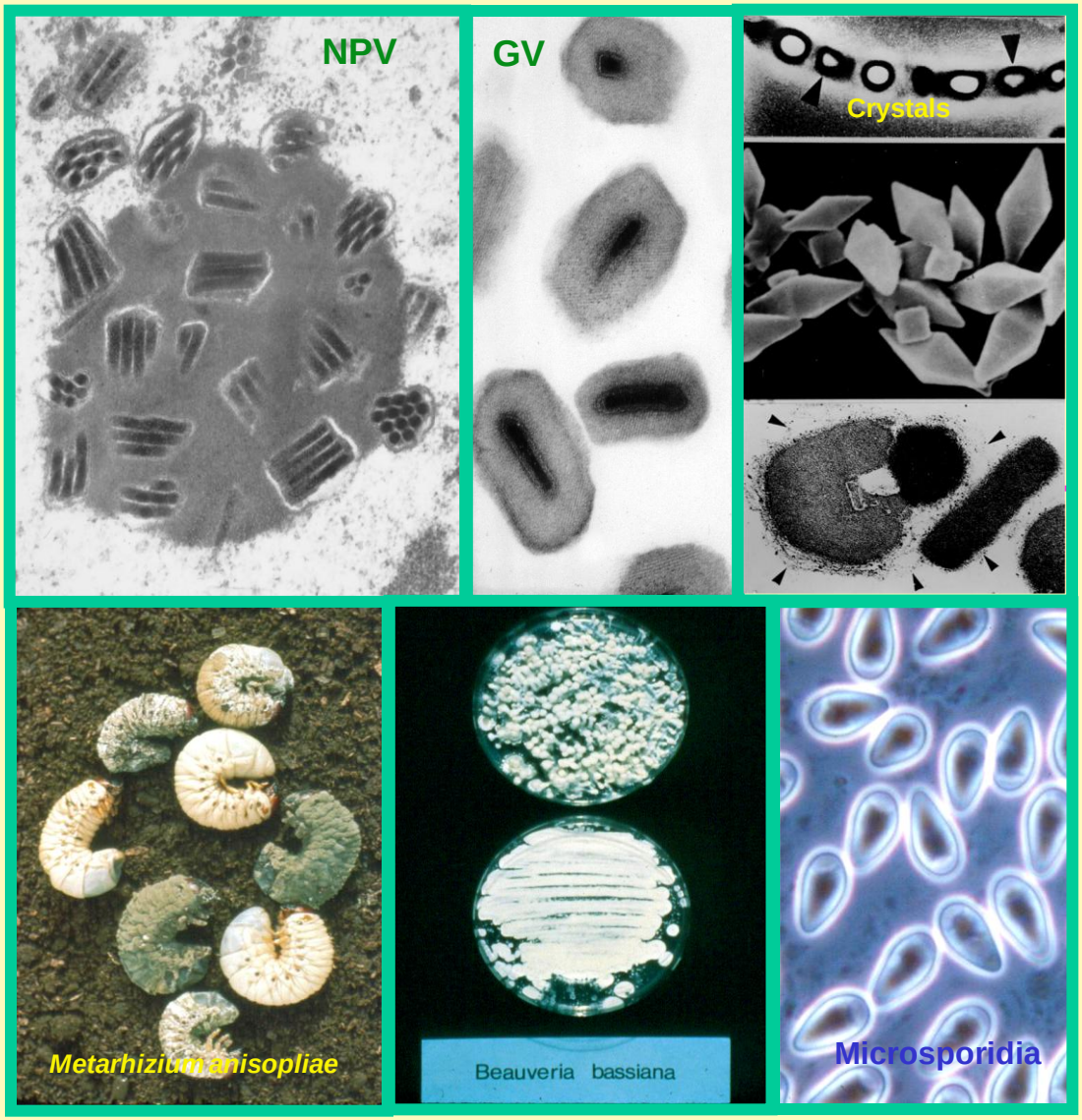
Microbial Control of Arthropods, Weeds and Plant Pathogens:
Risks, Benefits and Challenges
Shepherdstown, WV, November 28 - December 1, 2010

Principal Microbial Biocontrol Agents for Insects



For caterpillar pests

B. t. kurstaki

Cry1Ac
Cry1Ab
Cry1Ac
Cry2A

For mosquitoes

B. t. israelensis

Cry4A,
Cry4B
Cry11A
Cyt1A

Five Top Themes

1. **Classical Biological of insects with microbials is Very Rare**
   - A. The NPV of European spruce sawfly (in Canada & U.S. since 1940)
   - B. The fungus, *Entomophaga miamiaga* versus Gypsy moth (U.S.)?

2. **Wild Type NPVs & GVs and *B. thuringiensis* are highly specific**
   - > After 50 years, NO human affects, or significant non-target effects
   - > Much safer for the environment/non-targets than chemical insecticides

3. **Current regulations impede development & assessment**
   - > Could be "down-regulated" - Treated like insect-parasitic nematodes
   - > Cost-effectivenes/profit greater for high cash value crops

4. **Genetic engineering can improve efficacy markedly**

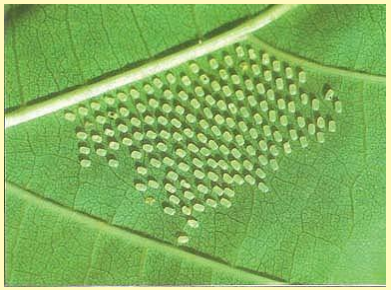
5. **Engineered microbial insecticides require greater scrutiny for:**
   - > Non-Target effects
   - > Depending on the host range, environmental fate

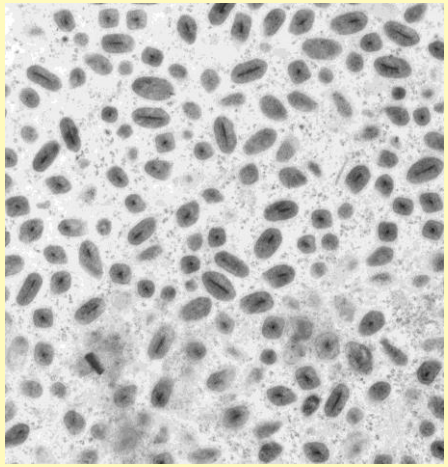
Microbial Biocontrols for Arthropods (mainly Insects)*

	Host Specificity	Mass Production	Economic Success
Viruses			
Baculoviruses			
Nuclear Polyhedrosis Viruses	**Very High**	**In vivo/Cumbersome**	**Niche Market**
Granulosis Viruses	**Very High**	**In vivo/Cumbersome**	**Niche Market**
Bacteria			
Bacillus thuringiensis **(most successful)**	**High**	**In vitro/Easy & Cheap**	**Moderate Marlet** **(led to GM Crops)**
Fungi			
Metarhizium anisopliae	**Moderate**	**In vitro & Improving**	**Several Niches**
Beauveria bassiana	**Moderate**	**In vitro & Improving**	**Several Niches**
Microsporidia			
Nosema locustae	**High**	**In vivo/Cumbersome**	**Niche Market**

* Less than 2% of the worldwide insecticide market control

Granulosis Virus of the the Grape Leaf Skeletonizer, *Harrisina brillians*

Applied once @

5 gm virus/acre

>90% control for

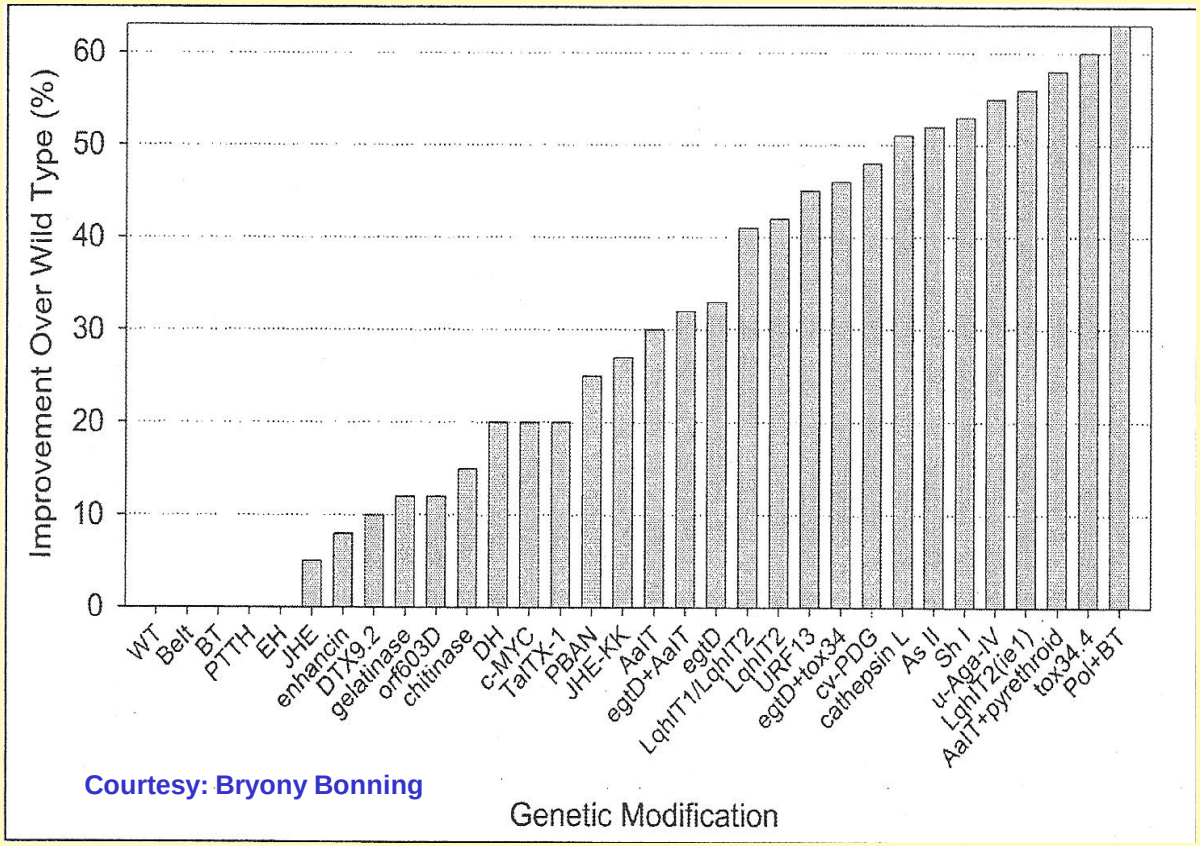
3 years

Example of a viral biocontrol agent that should not be regulated owing to its very high specificity

State of the Science

Nuclear Polyhedrosis Viruses

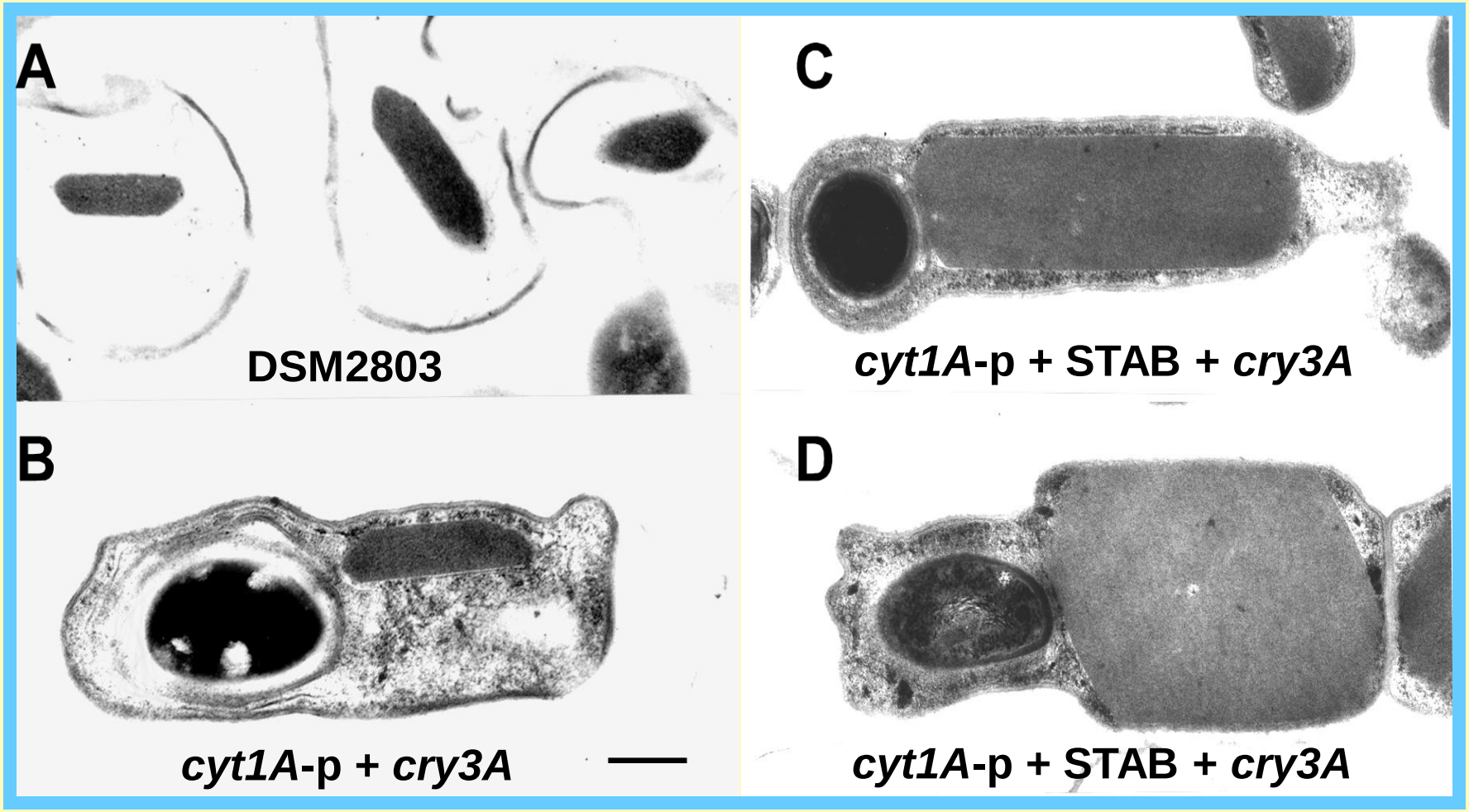
NPVs can be engineered to increase efficacy using various Enzymes and Neurotoxins



Regulatory Issue: Do engineered viruses have a broader host range, and if so, to what extent?

Bacillus thuringiensis

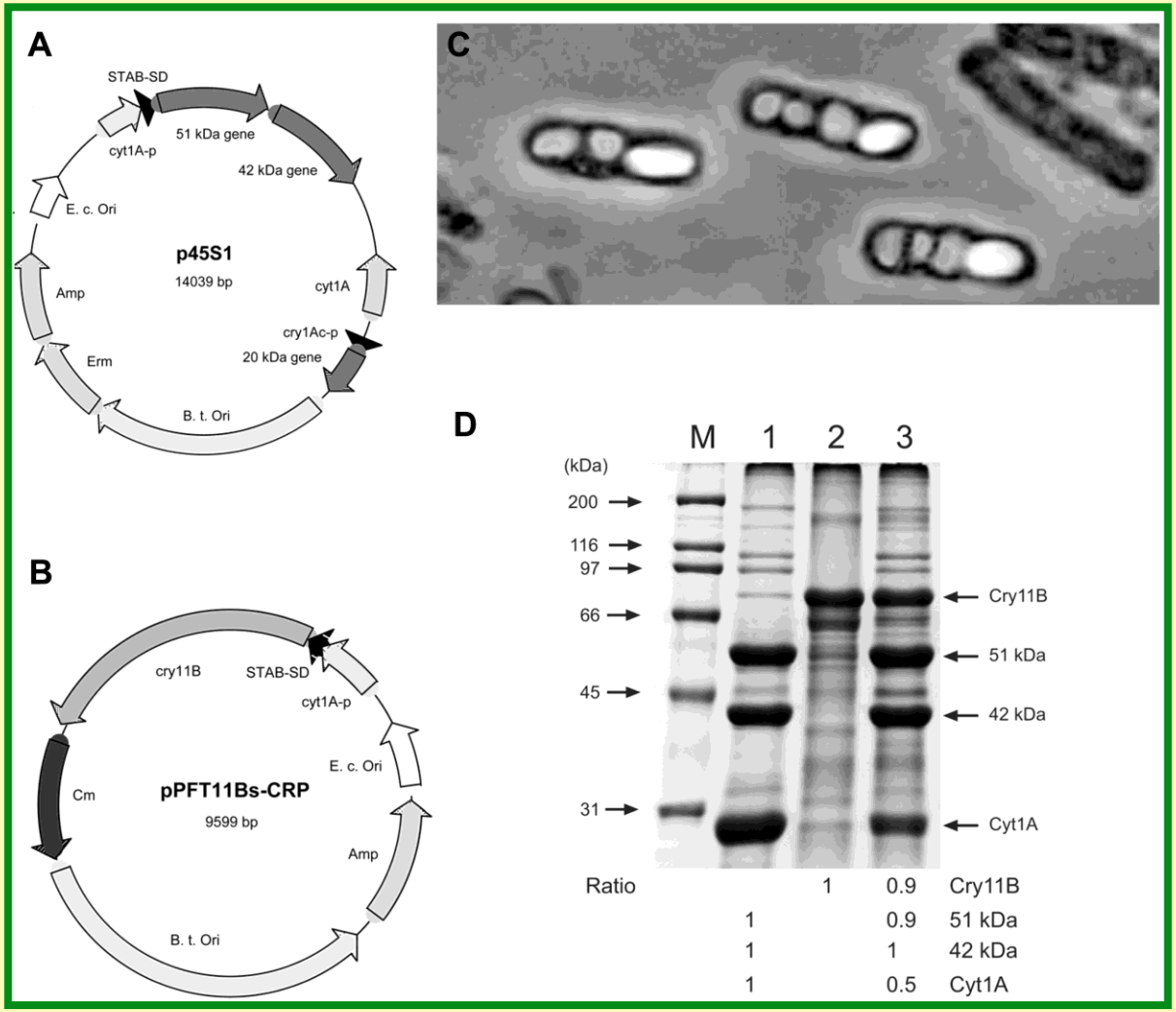
Multiple strong promoters combined with the mRNA stabilizing oligomer for synthesis of Cry3A



(Park *et al*., 1998. Appl Environ Microbiol 64: 3932 - 3938)

Engineered *Bacillus thuringiensis* with Three Endotoxins, each with a different mode of action

10 X more insecticidal than wild type parental species

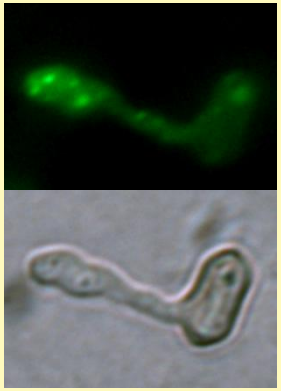


Regulatory Issue: Do engineered Bt's have a broader non-target spectrum?

Fungal Genes and Infection

Metarhizium anisopliae

MPL1, turgor pressure and penetration, 16-20 hrs pi

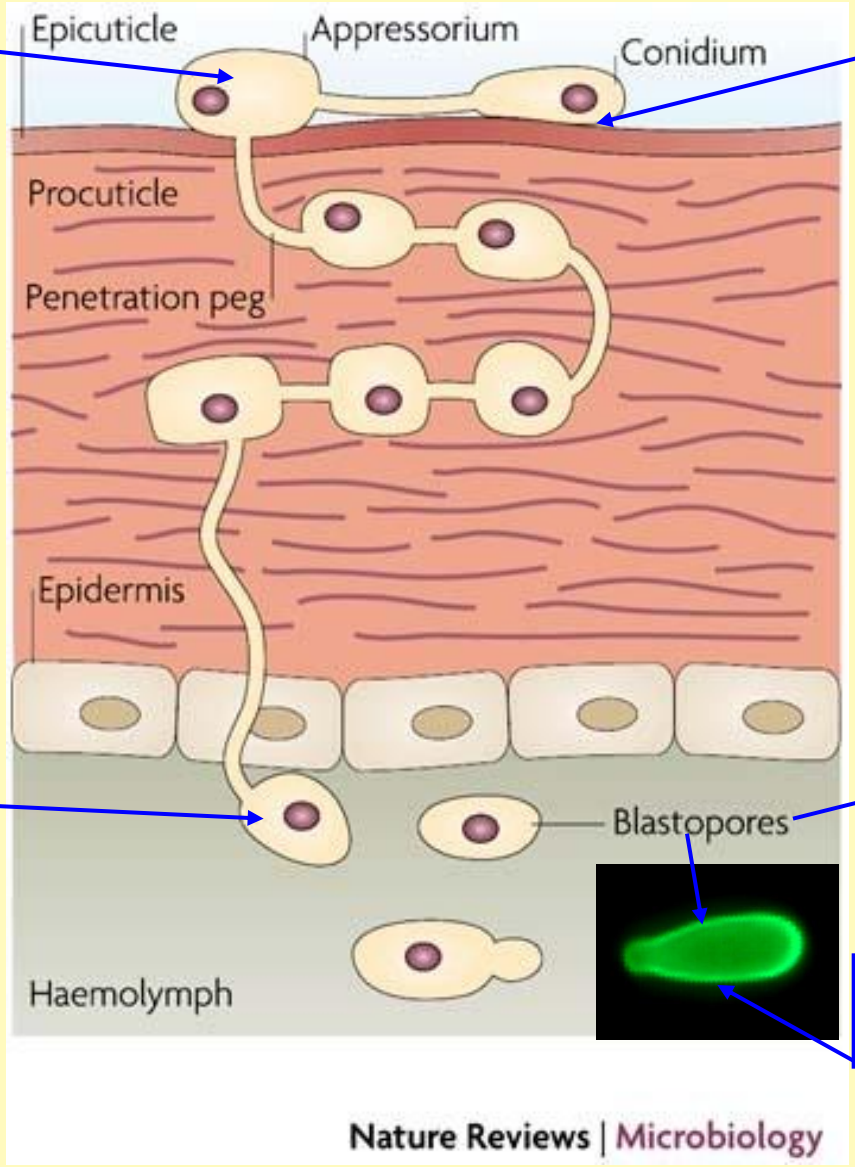


JBC, 2007. 282: 21110.

MOS1, osmosensor, 24-30 hrs pi

Eukaryot. Cell, 2008. 7: 302.

Courtesy Ray St. Leger



MAD1 adhesin, spore adhesion, 8-12hrs pi

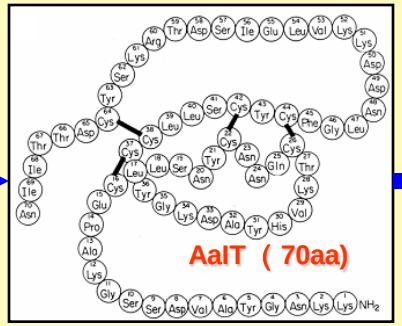
Eukaryot. Cell, 2007.6:808.

MCL1, Immune protective coat, 30-72 hrs pi

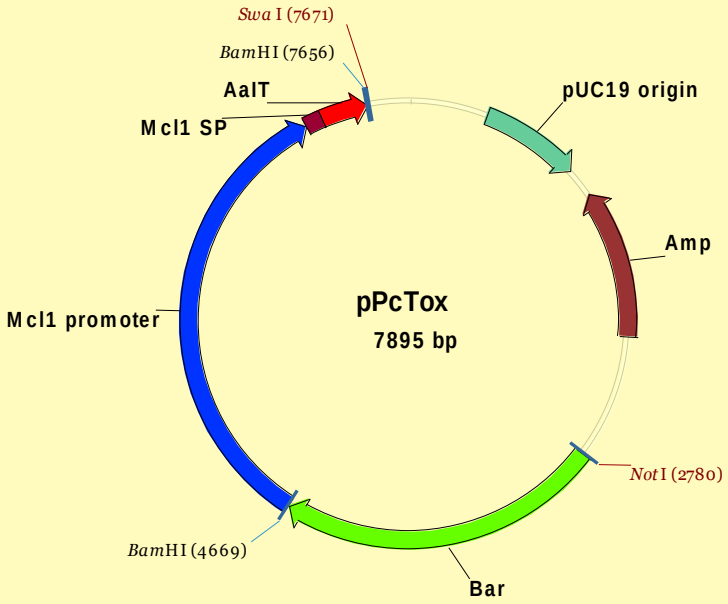
PNAS, 2006. 103: 6647.

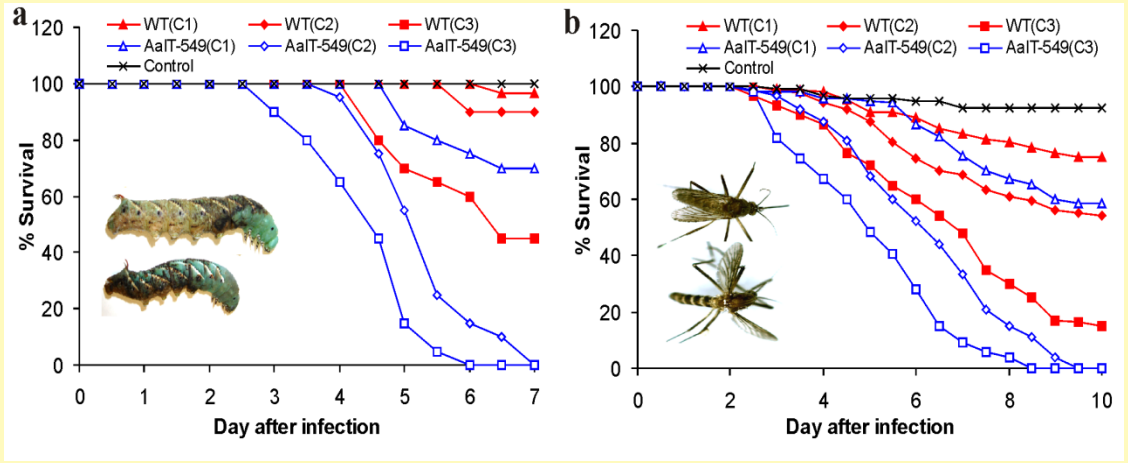
Metarhizium Genetic Engineering

Wang and St. Leger (2007) Nature Biotechnology 25:1455.



Gene synthesis





Bioassays

Regulatory Issue: Do engineered fungi have a broader non-target host spectrum?

Conclusions

NPVs, GVs, and *Bacillus thuringiensis* have a remarkable vertebrate and non-target invertebrate safety record spanning more than 50 years, justifying simplification of regulations for registration and use. Better public awareness of this record could enhance their acceptance.

Genetically engineered NPVs and strains of *Bacillus thuringiensis* have improved efficacy and cost-effectiveness, and appear to maintain a high degree of specificity, but invertebrate non-target studies are warranted.

Insect-pathogenic fungi such as *Metarhizium anisopliae* and *Beauveria bassiana* have the advantage over viruses and *Bacillus thuringiensis* of infecting insects via the cuticle, making them useful against both chewing and sucking insect pests, but many strains have a relatively broad host range, and thus require more rigorous non-target spectrum studies, especially for genetically engineered strains.

Recognized and reasonable vertebrate and invertebrate non-target studies of genetically engineered microbials will assist regulators in assisting and registering these potentially safe and useful products.

More specific fungi (including microsporidia), including entomophthoraceous fungi, with a few exceptions, should be treated by regulators more like insect-parasitic fungi. This should also be considered for wild type NPVs, GVs, and most strains of Bt.